



ORIGINAL ARTICLE

**Association between socioeconomic and biological factors and infant weight gain: Brazilian Demographic and Health Survey – PND5-2006/07<sup>☆,☆☆</sup>**



Jonas Augusto C. Silveira<sup>a,\*</sup>, Fernando Antônio B. Colugnati<sup>b</sup>, Ana Paula Poblacion<sup>a</sup>, José Augusto A.C. Taddei<sup>a</sup>

<sup>a</sup> Department of Pediatrics, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

<sup>b</sup> Núcleo Interdisciplinar de Estudos e Pesquisas em Nefrologia (NIEPEN), Nephrology Division, Universidade Federal de Juiz de Fora (UFJF), Juiz de Fora, MG, Brazil

Received 30 April 2014; accepted 27 August 2014

Available online 13 February 2015

**KEYWORDS**

Child;  
Weight gain;  
Nutritional disorders;  
Surveys;  
Brazil

**Abstract**

**Objective:** To examine the associations between socioeconomic and biological factors and infant weight gain.

**Methods:** All infants (0-23 months of age) with available birth and postnatal weight data (n = 1763) were selected from the last nationally representative survey with complex probability sampling conducted in Brazil (2006/07). The outcome variable was conditional weight gain (CWG), which represents how much an individual has deviated from his/her expected weight gain, given the birth weight. Associations were estimated using simple and hierarchical multiple linear regression, considering the survey sampling design, and presented in standard deviations of CWG with their respective 95% of confidence intervals. Hierarchical models were designed considering the UNICEF Conceptual Framework for Malnutrition (*basic, underlying and immediate causes*).

**Results:** The poorest Brazilian regions (-0.14 [-0.25; -0.04]) and rural areas (-0.14 [-0.26; -0.02]) were inversely associated with CWG in the *basic causes* model. However, this association disappeared after adjusting for maternal and household characteristics. In the final hierarchical

<sup>☆</sup> Please cite this article as: Silveira JA, Colugnati FA, Poblacion AP, Taddei JA. Association between socioeconomic and biological factors and infant weight gain: Brazilian Demographic and Health Survey – PND5-2006/07. J Pediatr (Rio J). 2015;91:284–91.

<sup>☆☆</sup> Study conducted at Departamento de Pediatria, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.

\* Corresponding author.

E-mail: [jonasnutri@yahoo.com.br](mailto:jonasnutri@yahoo.com.br) (J.A.C. Silveira).

**PALAVRAS-CHAVE**

Criança;  
Ganho de Peso;  
Distúrbios  
Nutricionais;  
Inquéritos;  
Brasil

model, lower economic status (-0.09 [-0.15; -0.03]), human capital outcomes (maternal education < 4th grade (-0.14[-0.29; 0.01]), higher maternal height (0.02[0.01; 0.03])), and fever in the past 2 weeks (-0.13[-0.26; -0.01]) were associated with postnatal weight gain.

**Conclusion:** The results showed that poverty and lower human capital are still key factors associated with poor postnatal weight gain. The approach used in these analyses was sensitive to characterize inequalities among different socioeconomic contexts and to identify factors associated with CWG in different levels of determination.

© 2015 Sociedade Brasileira de Pediatria. Published by Elsevier Editora Ltda. All rights reserved.

### Associação entre fatores socioeconômicos e biológicos e o ganho de peso de lactentes: Pesquisa Nacional de Demografia e Saúde (PNDS) de 2006/07

#### Resumo

**Objetivo:** Examinar as associações entre fatores socioeconômicos e biológicos e o ganho de peso de lactentes.

**Métodos:** Foram selecionados todos os lactentes (0-23 meses de idade) com dados de peso ao nascer e pós-natal avaliados na última pesquisa com representatividade nacional realizada no Brasil (2006/07) por amostragem probabilística complexa. A variável de resultado foi o Evolução Ponderal Condicional (CWG), que representa quanto um indivíduo desviou de seu ganho de peso esperado, considerando o peso ao nascer. As associações foram estimadas utilizando regressão linear simples e múltipla hierárquica, considerando o plano amostral da pesquisa e apresentadas em desvios padrão do CWG com seus respectivos intervalos de confiança de 95%. Os modelos hierárquicos foram estruturados considerando o Modelo Conceitual de Desnutrição da UNICEF (*causas básicas, inerentes e imediatas*).

**Resultados:** As regiões brasileiras mais pobres (-0,14[-0,25; -0,04]) e a área rural (-0,14[-0,26;-0,02]) foram inversamente associadas ao CWG no modelo de *causas básicas*. Contudo, essa associação desapareceu após o ajuste pelas características maternas e do ambiente familiar. No modelo hierárquico final, a baixa condição econômica (-0,09[-0,15; -0,03]), as variáveis de capital humano (escolaridade materna < 5º ano (-0,14[-0,29; -0,01])), maior estatura materna (0,02[0,01; 0,03]) e febre nas duas semanas anteriores à pesquisa (-0,13[-0,26; -0,01]) foram inversamente associadas ao ganho de peso pós-natal.

**Conclusão:** Os resultados mostraram que a pobreza e baixo capital humano ainda são fatores fundamentais associados ao ganho de peso pós-natal abaixo de esperado. A abordagem utilizada em nossas análises foi sensível ao caracterizar desigualdades entre diferentes contextos socioeconômicos e ao identificar fatores associados ao CWG em diferentes níveis de determinação.

© 2015 Sociedade Brasileira de Pediatria. Publicado por Elsevier Editora Ltda. Todos os direitos reservados.

## Introduction

Nutritional disorders are cyclically determined by cultural, social, economic, and biological factors at different levels, from the most proximal, such as food availability and the occurrence of diseases, to distal factors such as access to information and the cultural superstructure.<sup>1,2</sup>

The first two years of life are characterized by accelerated growth and development, which require high nutritional intake and define infants as a group with high biological vulnerability, especially considering that, by this time, growth and development are more strongly determined by environmental factors than by genetic characteristics.<sup>3,4</sup> Nutritional disorders beginning in this period are associated with increased mortality, increased susceptibility to infectious diseases, impaired psychomotor development, academic underachievement, and lower productive capacity in adulthood.<sup>1,4-6</sup>

In Brazil, the predominant nutrition and health policies and programs, such as the exclusive breastfeeding campaign, immunization and supplementation programs, and the food fortification initiative, address infants and their mothers. The main Brazilian social support programs are known as "Fome Zero" and "Plano Brasil Sem Miséria", which aim to promote household food security and autonomy for low-income families by means of conditional cash transfers, the funding of family farming, and aid for purchasing goods and services.<sup>7,8</sup>

National health surveys are important tools to evaluate such public policies because they describe the health and nutrition profile of the population, identifying risk factors, to allow comparisons among regions and countries as well as the plotting of trends over time.<sup>9,10</sup> Therefore, given the significance of children's growth in the first two years of life<sup>3</sup> and using data from the last Brazilian National Survey on Demography and Health of Women and Children

(PNDS-2006/07), this study aimed to examine the associations between socioeconomic and biological conditions and postnatal weight gain.

## Materials and methods

### Study design and settings

The PNDS-2006/07 was a national survey conducted between November of 2006 and May of 2007, focused on the health and nutrition of women of reproductive age (15-49 years old) and children under 5 years of age, including social, economic and cultural factors. The PNDS-2006/07 used complex probability sampling in two stages: the primary sampling unit was the census area, and the secondary sampling unit was the household. The study group comprised only private households (including slums). Eligible households were selected at random, taking into account the number of census areas in each region and the urban/rural areas. Further details on methodology, including sampling design and data collection, have been reported elsewhere.<sup>11</sup>

### Eligibility and selection criteria

The households considered eligible included at least one woman of reproductive age. Data were collected from all children under 59 months for each eligible mother. For the purpose of this study, the authors selected the subgroup of infants (0–23 months of age) living in the same house as their mothers.

### Data collection and variables definition

Data were collected by pairs of trained female field workers in the children's residence. Children were weighed using an electronic portable scale (Y60) with precision of 100 g (Dayhome®, São Paulo, SP, Brazil).<sup>11</sup> Birth weight was collected from the child's maternity card, and when not available, by mother's recall. Weight-for-age Z-score (WAZ) was calculated using *macros* of the World Health Organization (WHO) Anthro Software version 3.2.2 for Stata and the WHO Child Growth Standards were used for anthropometric classification.<sup>12</sup>

Conditional weight gain (CWG) – the outcome variable – represents a child's deviation from the expected weight gain, given his/her birth weight, and is expressed in standard deviations (SD). CWG is derived from the standardized residuals obtained from a sex-specific linear regression adjusted for WAZ at birth and age at survey, where WAZ at survey is the dependent variable.

It is important to consider this approach in longitudinal analysis of individuals' growth, since it: 1) overcomes the statistical phenomenon of regression to the mean, where extreme values tend to move closer to the sample mean; 2) incorporates the different ages at survey's date; and, 3) deals with the collinearity of dependent weight measures.<sup>13,14</sup> For example, if a child with high birth weight reduces his or her WAZ, likewise for the rest of the children in the sample who were born with high birth weight, the CWG would be ~0 SD; but, in a counterfactual perspective,

if this child keeps the same WAZ when the rest of the sample's WAZ tends to reduce, his or her CWG would be greater than zero SD.

The rationale for the selection of the exposure variables was based on UNICEF's Conceptual Framework of Malnutrition, which considers the basic, underlying, and immediate determinants. The Conceptual Framework of Malnutrition is a useful tool that helps to organize possible causes of nutritional disorders and identify situations where investigations or interventions are required.<sup>2</sup>

Two variables were included as *basic causes*: children's area of residence (urban/rural) and regions, dichotomized as South and Southeast or as North, Northeast, and Midwest; this approach was used to contrast socioeconomic differences, the latter regions being more deprived.

As *underlying causes*, some household and maternal factors were considered. Economic status was assessed by a validated asset-based questionnaire, which classifies households into eight mean family income categories,<sup>15</sup> which were reduced to four categories (A1-C1/C2/D/E); the categories A1-C1 (richest) were merged to produce balanced cell sizes in each category. Household food insecurity was assessed using the Brazilian Food Insecurity Scale (EBIA, in Portuguese) a translated and validated version of the USDA Food Security Module, known currently as the US Household Food Security Survey Measure – which classifies the household's in food security level as mild, moderate or severe food insecurity.<sup>16,17</sup> Human capital outcomes (maternal education level [ $< 4^{\text{th}}$  grade] and height [cm]), age at birth ( $< 18$  years), parity (number of deliveries), prenatal care (number of visits), and type of delivery (vaginal/caesarean) were also included.

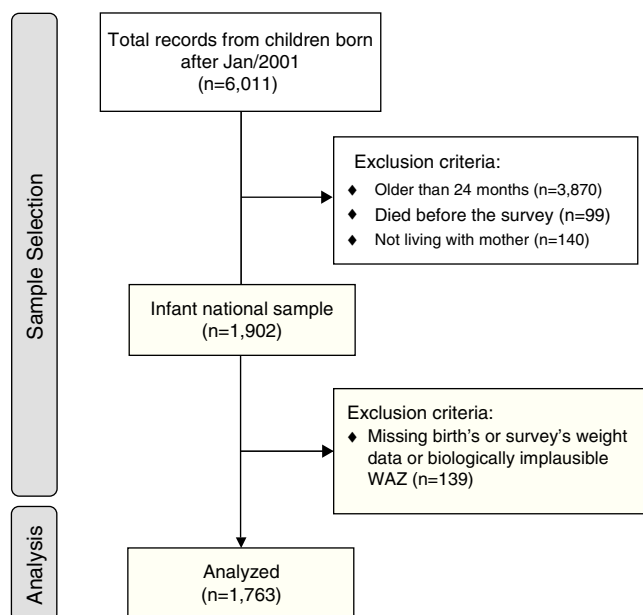
Lastly, fever or diarrhea in the previous two weeks; hospitalization due to diarrhea, pneumonia, or bronchitis in the previous 12 months; duration of exclusive breastfeeding ( $< 1$  month/1-4 months/ $> 4$  months); age; and sex were considered as *basic causes*.

### Data analysis

Data were merged and analyzed using Stata software (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP, USA), considering the stratification and clustering effects of the complex sampling design. Sample weights were only applied to the descriptive statistics to avoid overestimating subgroups.<sup>10</sup>

In the analytical approach, simple and multivariable linear regression analyses were performed. The multivariable regression was conducted by applying a hierarchical structure to the analysis,<sup>18</sup> considering the UNICEF's Framework for Malnutrition.<sup>2</sup> Initially, all variables were tested by a simple linear regression and those with p-value  $< 0.20$  were considered eligible for multivariable analyses, within each level of determination. Then, a multivariable analysis was performed for variables considered in the *basic causes* (Model 1), adjusted for age and sex. This procedure was repeated for the set of *underlying* (Model 2) and *immediate causes* (Model 3).

Additionally, these models were adjusted for the previous model, following the hierarchical sequence – that is Model 2 was adjusted for Model 1, and Model 3 was adjusted for



WAZ, weight-for-age Z-score.

**Figure 1** Flow diagram of final sample selection. WAZ, weight-for-age Z-score.

Model 2 and 1. Model 3 was also controlled for the source of birth weight data (maternity card or mother's recall). The coefficients were reported as the SD of CWG with their respective 95% confidence intervals (in parenthesis or square brackets through the text). Following the technical literature recommendations, estimates were interpreted in terms of their relevance toward the subject, effect size, and inherent uncertainties, represented herein as the 95% confidence intervals, avoiding the usual accept/reject approach based on the  $p$ -value  $< 0.05$  cut-off.<sup>19</sup>

## Ethical Aspects

All procedures involving human subjects in the PNDS-2006/07 were approved by the Research Ethics Committee of the Center of Reference and Training on STD/HIV of São Paulo's State Health Department. The present research was approved by the Research Ethics Committee of the Universidade Federal de São Paulo – CEP/UNIFESP.

## Results

Of the 6,011 children born after January 2001 who were available in the dataset, 1,763 were infants (0-23 months of age) living in the same house as their mothers, having biologically plausible WAZ data ( $-6$  to  $+5$  SD) at birth and at survey date (Fig. 1). The sample's characteristics are described in Table 1.

Diarrhea in the past two weeks, duration of exclusive breastfeeding and hospitalization for diarrhea, pneumonia, and bronchitis in the past 12 months were not considered for multivariable analyses ( $p$ -value  $> 0.20$ ). Sex was kept in the models to adjust for potential sex-related confounding.

Sample losses occurred in the Models 2 and 3 due to missing values in the dataset (Table 2).

Both *basic causes* were inversely associated with the CWG (Table 2 – Model 1). However, this association was lost after adjusting the model for *underlying causes* (Model 2). When adjusted for *immediate causes* (Model 3), economic status ( $-0.09$  [ $-0.15$ ;  $-0.03$ ]), maternal education ( $-0.14$  [ $-0.29$ ;  $-0.01$ ]), and fever in the past two weeks ( $-0.13$  [ $-0.26$ ;  $-0.01$ ]) were inversely associated with children's weight gain. However, each 1 cm increment in maternal height was associated with an increase of 0.02 SD (0.01; 0.03) in children's post-natal weight gain.

## Discussion

Using data from the PNDS-2006/07, the most recent survey with national representativeness conducted in Brazil, it was possible to identify the level of association between a set of factors – in different hierarchical levels of determination – and postnatal weight gain among Brazilian infants. It was found that lower economic status and maternal education and fever in the past two weeks had a negative impact on postnatal weight gain, and that maternal height was positively associated with CWG.

Although geographical factors were highly associated with CWG in Model 1, when the maternal and household characteristics were introduced in the hierarchical model (Model 2), the association between geographical factors and CWG disappeared, and was replaced by economic status and higher maternal height; low maternal education presented only a moderate association. However, when the third level (*immediate causes*) was introduced into the analysis, fever remained associated with CWG and the level of association between low maternal education and CWG increased.

The trajectory of growth is mediated by a complex network of non-mutually exclusive factors, acting at different levels of causation, from social, economic, and political determinants; followed by access to health services, food security, income, and educational level; to individual factors related to the burden of disease, eating/feeding practices, metabolic programming, and genetic factors.<sup>2,3,20</sup>

The present results demonstrated that low income and maternal educational levels are still key factors to weight faltering. However, contrary to expected, geographical characteristics were not independent factors associated with CWG. This lack of association may be a consequence of the coverage expansion of the public primary health care system in Brazil<sup>8</sup> and/or the intense migratory process from the poorest to the richest regions and from rural to urban areas.<sup>21</sup> However, this statement may not hold true for geographical disparities within neighborhoods or cities.<sup>22,23</sup>

Besides geographical factors, the lack of association of CWG and diarrhea can also be explained by the improvement of health and sanitation systems. The increased access to health services enables the provision of adequate rehydration and antibiotic therapy to infants, which prevents important acute weight loss and/or promotes faster recovery.<sup>8,24,25</sup> Moreover, one of the components of social programs in Brazil consists of having young children periodically evaluated by health practitioners. Together with the expansion of the water supply and sewerage,

**Table 1** Characteristics of Brazilian infants from the Brazilian Children's and Women's Demographic and Health Survey – PNDS – 2006/07.

Characteristics	n <sup>a</sup>	μ or P <sup>b</sup>	95% CI	Characteristics	n <sup>a</sup>	μ or P <sup>b</sup>	95% CI
<b>Biological characteristics</b>				<i>Maternal height (cm)</i>	1,754	157.7	157.1; 158.3
<i>Age (months)</i>	1,763	11.2	10.6; 11.7	<i>Prenatal (No. of visits)<sup>e</sup></i>	1,707	7	6; 9
<i>Gender (%)</i>	1,763			<i>Delivery (%)</i>	1,762		
Boys	928	52.4	47.8; 57.0	Caesarean	772	45.3	40.1; 50.6
Girls	835	47.6	43.0; 52.2	Other	990	54.7	49.4; 59.9
<i>Birth weight (kg)</i>	1,763	3.25	3.21; 3.30	<i>Parity (No. of deliveries)<sup>e</sup></i>	1,763	2	1; 3
<i>WAZ at birth</i>	1,763	-0.13	-0.22; -0.03	<i>Food and Nutrition Security (%)</i>	1,710		
<i>WAZ at survey</i>	1,763	0.17	0.08; 0.25	Security	879	53.8	48.7; 58.8
<i>Nutritional status at survey (%)</i>	1,763			Mild insecurity	473	28.4	24.1; 33.0
Underweight (WAZ < -2)	61	2.9	1.9; 4.5	Moderate insecurity	230	13.1	9.8; 17.3
Normal weight (WAZ ± 2)	1,604	93.3	91.3; 94.8	Severe insecurity	128	4.7	3.6; 6.2
Overweight (WAZ > 2)	98	3.8	2.7; 5.2				
<b>Basic Causes</b>				<i>Immediate Causes</i>			
<i>Region (%)</i>	1,763			<i>Diarrhea (%)<sup>c</sup></i>	1,760		
S and SE	647	54.2	48.9; 59.4	Yes	233	12.2	9.8; 15.1
N, NE, and MW	1,116	45.8	40.6; 51.1	No	1,527	87.8	84.9; 90.2
<i>Residence area (%)</i>				<i>Fever (%)<sup>c</sup></i>	1,761		
Urban	1,200	83.2	78.4; 87.0	Yes	450	26.2	22.8; 29.8
Rural	563	16.8	12.9; 21.6	No	1,311	73.8	70.2; 77.2
				<i>Hospitalization<sup>d</sup></i>	1,763		
<b>Underlying Causes</b>				Yes	139	7.8	5.7; 10.6
<i>Economic status (%)</i>	1,550			No	1,624	92.2	89.4; 94.3
A1-C1 (richest)	486	34.6	29.0; 40.7	<i>Exclusive breastfeeding (%)</i>	1,477		
C2	356	23.5	19.0; 28.6	< 1 month	502	31.8	27.2; 36.8
D	446	29.1	24.4; 34.2	1-4 months	484	33.6	28.9; 38.6
E	265	12.9	10.3; 16.0	> 4 months	491	34.6	30.4; 39.1
<i>Maternal education (%)</i>							
< 4 <sup>th</sup> grade	378	17.7	14.6; 21.3				
≥ 4 <sup>th</sup> grade	1,379	82.3	78.6; 85.4				

μ, mean; P, prevalence; CI, confidence interval; WAZ, weight-for-age Z-score; S, South; SE, Southeast; N, North; NE, Northeast; MW, Midwest.

<sup>a</sup> Number of subjects in database.

<sup>b</sup> Mean or prevalence based on the weighted sample.

<sup>c</sup> In the past two weeks.

<sup>d</sup> Hospitalization in the past 12 months for diarrhea, pneumonia, or bronchitis.

<sup>e</sup> Expressed as median and interquartile range.

**Table 2** Linear models of association between environmental and individual factors and conditional weight gain (CWG) among Brazilian infants – PNDS - 2006/07.

Variables	Reference	Bivariable			Model 1			Model 2			Model 3			
		$\beta$	95% CI	p	$\beta$	95% CI	p	$\beta$	95% CI	p	$\beta$	95% CI	p	
<i>Basic Causes</i>														
Region	N, NE, and MW	-0.13	-0.24; -0.03	0.012	-0.14	-0.25; -0.04	0.007							
Residence area	Rural	-0.13	-0.25; -0.01	0.036	-0.14	-0.26; -0.02	0.024							
<i>Underlying causes</i>														
Economic status <sup>a</sup>	A1-C1	-0.18	-0.23; -0.13	0.000				-0.09	-0.16; -0.03	0.003	-0.09	-0.15; -0.03	0.004	
Food insecurity <sup>b</sup>	Food Security	-0.11	-0.16; -0.05	0.000										
Maternal education	< 4 <sup>th</sup> grade	-0.26	-0.39; -0.13	0.000				-0.13	-0.28; 0.02	0.090	-0.14	-0.29; 0.01	0.068	
Maternal height	Cm	0.02	0.01; 0.03	0.000				0.02	0.01; 0.03	0.000	0.02	0.01; 0.03	0.000	
Prenatal	No. of visits	0.02	0.01; 0.04	0.001										
Delivery	Caesarean	0.18	0.08; 0.28	0.000										
Parity	No. of siblings	-0.07	-0.11; -0.03	0.000										
<i>Immediate causes</i>														
Diarrhea <sup>c</sup>	Yes	-0.10	-0.25; 0.06	0.219										
Fever <sup>c</sup>	Yes	-0.14	-0.26; -0.03	0.013							-0.13	-0.26; -0.01	0.033	
EB <sup>d</sup>	> 1 month	0.00	-0.07; 0.07	0.940										
Hospitalization <sup>e</sup>	Yes	0.07	-0.12; 0.25	0.466										
Age	Months	0.01	0.00; 0.02	0.000	0.01	0.00; 0.02	0.000	0.01	0.00; 0.02	0.001	0.01	0.00; 0.02	0.001	
Sex	Female	0.01	-0.08; 0.11	0.800										

Model 1: n = 1,763 – adjusted for age and sex; Model 2: n = 1,448 – adjusted for Model 1, household food insecurity, prenatal, type of delivery, and parity; Model 3: n = 1,447 – adjusted for Model 2 and source of birth weight data (maternity card/mother's recall).

EB, exclusive breastfeeding.

<sup>a</sup> Ordinal variable: A1-C1, C2, D, E.

<sup>b</sup> Ordinal variable: food security, mild food insecurity, moderate food insecurity, severe food insecurity.

<sup>c</sup> In the past two weeks.

<sup>d</sup> Ordinal variable: < 1 month, 1-4 months,  $\geq$ 4 months.

<sup>e</sup> In the past 12 months for diarrhea, pneumonia, or bronchitis.



Brazil has substantially reduced nutritional disorders and mortality rates from acute infections.<sup>8,25</sup>

The associations found here depict a society in transition, where geographical characteristics or acute diseases are no longer major determinants of negative nutritional disorders, but low socioeconomic status and educational attainment still are. It contrasts with high-income countries, where weight faltering is most attributed to higher parity, low appetite, weaning/feeding/eating difficulties, or lack of positive interactions between infants and parents.<sup>26</sup> This study also observed an inverse and significant association between parity and CWG; however, it was not sustained after adjusting for the other factors. This may have occurred due to the relationship between higher parity and lower income and educational levels in Brazil.<sup>27</sup>

Although food insecurity and income level are related variables, in the present analysis economic status performed better as explanatory variable of CWG. The authors attribute this to the fact that the questions in the EBIA are related to any event of food insecurity in the past three months, without considering the frequency of events; furthermore, the process for a family to improve their economic status may require considerable time (even generations). The CWG was sensitive to such difference and, therefore, it is reasonable to consider that infants were exposed to the same or similar economic environment described at survey since birth, considering that those living in less privileged households experienced poorer postnatal weight gain compared to those from wealthy families.

The variation in the effect size and the level of association between low maternal education and CWG in the bivariate and multivariate analyses was noteworthy. The same rationale described previously can be used to explain such variation, since economic status and educational level are related variables. However, there was some effect on CWG that was not fully explained by economic status, and after adding the occurrence of fever in the previous two weeks, the level of association between low maternal education and poor weight gain increased.

Lack of maternal education is a recognized risk factor for negative health outcomes<sup>28</sup> and, in this context, this result was interpreted as the maternal inability to provide adequate care, either due to the inability to recognize the development of an infectious process, or delay in seeking health services. The impact on weight gain is a consequence of increased energy expenditure and reduced food intake, due to the anorectic effect of pro-inflammatory cytokines on appetite regulatory hormones (i.e. leptin) and neuropeptides (i.e. neuropeptide Y) during the acute phase response.<sup>29</sup> Considering the family's socioeconomic status in this equation – that is, living in an unhealthy environment – these infants may have experienced multiple infectious events during their lives.

Finally, the positive association between maternal height and child weight gain should not be interpreted solely as a consequence of shared genetic characteristics, but also as a milieu of inadequate health and nutrition during a woman's childhood (compromising her growth and, consequently, reproductive organ size) and pregnancy (insufficient provision of nutrients impairing intrauterine growth).<sup>3</sup> This relationship highlights the importance of improving not only

infants' but also women's health and nutritional status to break this cycle.

Using data from the ALSPAC cohort, Din et al.<sup>30</sup> compared the patterns of weight gain among children who had "early weight faltering" (< 5<sup>th</sup> percentile of weight gain at 8 weeks), "late weight faltering" (< 5<sup>th</sup> percentile of weight gain at 9 months), and a control group. Similarly to the present study, they observed a positive association between age and CWG. The pattern of weight gain was different depending on when the weight faltering occurred, but by the age of 13 years these children substantially recovered weight; however, their standardized mean weight and height was statistically different from the control group.

Such findings highlight the importance of preventing nutritional disorders during the first 1,000 days of life – from conception to 2 years of age – because damages that occur in this period will be reflected in long-term health and human capital outcomes.<sup>3</sup>

The main strengths of this study include its basis on the most recent representative sample of the Brazilian population, designed and conducted by a team of experienced researchers, who used CWG to evaluate children's growth; thus, these results have not only internal validity, but also can be generalized to all Brazilian infants and, although the PNDS dates from 2006/07, it is considered that the findings are still valid, since no major political or structural changes have occurred in Brazilian society in the last several years. However, a new PNDS is needed to update the knowledge about the current children's nutritional and health status in Brazil, allowing comparisons with previous national and international health surveys.

It is important to consider two limitations in the interpretation of this study. First, although the PNDS-2006/07 included slums in the household sample, it did not consider institutionalized (i.e. hospital or orphanage), homeless, or children living in settlements; second, the mortality bias, which is related to the death of children who were born under inadequate conditions or were exposed to adverse conditions during the gestational period. Therefore, these findings cannot be generalized to children living under the described circumstances, and furthermore, these limitations may have underestimated the magnitude and level of association of the results.

Contrary to the attained nutritional status (i.e., WAZ), the CWG is generated considering the birth weight, which allows for the analysis of how much a child deviated from his/her expected weight gain, considering his/her peers, providing a better measure of environmental influences of growth. However, this is a measure exclusive to academic research, and cannot feasibly be used in a clinical setting.

Regardless, its interpretation has important clinical and public health implications. It highlights the importance of tracking infants' weight gain, particularly among those living in poorer contexts and whose mothers have lower education. To break the cycle of intergenerational negative effects on child growth, special attention regarding health and education should be given to girls and women. In terms of public health, this approach was sensitive in identifying factors associated with postnatal weight gain and quantifying the size and direction of the associations, which may be a useful tool to evaluate programs targeted at improving children's and women's nutrition and health status and human capital.

These results showed that poverty and lower human capital are still key factors associated with poor postnatal weight gain. The approach used was sensitive in characterizing inequalities among different socioeconomic contexts and in identifying factors at different levels of determination associated with CWG.

## Funding

The Brazilian Children's and Women's Demographic and Health Survey 2006/07 was funded by the Ministry of Health and executed by the Brazilian Center for Analysis and Planning (CEBRAP). The author JS received a scholarship from *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP) protocol no. 2011/17736-4. The author AP received a scholarship from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). The author JT is partially funded by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

## Conflicts of interest

The authors declare no conflicts of interest.

## References

- World Health Organization. Physical status: the use and interpretation of anthropometry - report of a WHO Expert Committee. WHO Technical Report Series: WHO Library; 1995.
- United Nations Children's Fund., Strategy for improved nutrition of children and women in developing countries. New York: UNICEF; 1990.
- Martorell R, Zongrone A. Intergenerational influences on child growth and undernutrition. *Paediatr Perinat Epidemiol*. 2012;26:S302-14.
- Victora CG, de Onis M, Hallal PC, Blossner M, Shrimpton R. Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics*. 2010;125:e473-80.
- Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*. 2008;371:243-60.
- Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, et al. Maternal and child undernutrition: consequences for adult health and human capital. *Lancet*. 2008;371:340-57.
- Brasil, Ministério da Saúde. Política Nacional de Alimentação e Nutrição. Brasília: Ministério da Saúde; 2012.
- Victora CG, Aquino EM, do Carmo Leal M, Monteiro CA, Barros FC, Szwarcwald CL. Maternal and child health in Brazil: progress and challenges. *Lancet*. 2011;377:1863-76.
- Ramalingaswami V. New global perspectives on overcoming malnutrition. *Am J Clin Nutr*. 1995;61:259-63.
- Heeringa SG, West BT, Berglund PA. Applied survey data analysis. 1<sup>st</sup> ed Boca Raton: Chapman and Hall/CRC; 2010.
- Berquó E, Garcia S, Lago T. Aspectos metodológicos - Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher - PNDS 2006. [cited 04 Apr 2014]. Available from: <http://bvsm.saude.gov.br/bvs/pnds/img/Metodologia.PNDS2006.pdf>
- World Health Organization., WHO., Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. Geneva: The World Health Organization; 2006.
- Cole TJ. Conditional reference charts to assess weight gain in British infants. *Arch Dis Child*. 1995;73:8-16.
- Cole TJ. Presenting information on growth distance and conditional velocity in one chart: practical issues of chart design. *Stat Med*. 1998;17:2697-707.
- Associação Brasileira de Empresas de Pesquisa (ABEP). Critério de Classificação Econômica Brasil (CCEB). 2009. [cited 04 Apr 2014]. Available from: <http://www.abep.org/novo/FileGenerate.ashx?id=251>
- Brasil, Ministério da Saúde. Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher - PNDS 2006: dimensões do processo reprodutivo e da saúde da criança. Ministério da Saúde: Brasília, 2009. [cited 04 Apr 2014]. Available from: <http://bvsm.saude.gov.br/bvs/publicacoes/pnds.crianca.mulher.pdf>
- Kepple AW, Segall-Correa AM. Conceptualizing and measuring food and nutrition security. *Cien Saude Colet*. 2011;16:187-99.
- Victora CG, Huttly SR, Fuchs SC, Olinto MT. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. *Int J Epidemiol*. 1997;26:224-7.
- Gardner MJ, Altman DG. Confidence intervals rather than P values: estimation rather than hypothesis testing. *Br Med J (Clin Res Ed)*. 1986;292:746-50.
- Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet*. 2013;382:427-51.
- Brito F. The displacement of the Brazilian population to the metropolitan areas. *Estud Av*. 2006;20:221-36.
- Carter MA, Dubois L, Tremblay MS, Taljaard M. The influence of place on weight gain during early childhood: a population-based, longitudinal study. *J Urban Health*. 2013;90:224-39.
- Spray AL, Eddy B, Hipp JA, Iannotti L. Spatial analysis of undernutrition of children in Léogâne Commune. *Haiti Food Nutr Bull*. 2013;34:444-61.
- Melli LC, Waldman EA. Temporal trends and inequality in under-5 mortality from diarrhea. *J Pediatr (Rio J)*. 2009;85:21-7.
- Victora CG. Diarrhea mortality: what can the world learn from Brazil? *J Pediatr (Rio J)*. 2009;85:3-5.
- Shields B, Wacogne I, Wright CM. Weight faltering and failure to thrive in infancy and early childhood. *BMJ*. 2012;345:e5931.
- Huttly SRA, Barros FC, Victora CG, Lombardi C, Vaughan JP. Subsequent pregnancies: who has them and who wants them? Observations from an urban center in Southern Brazil. *Rev Saude Publica*. 1990;24:212-6.
- Chen Y, Li H. Mother's education and child health: is there a nurturing effect? *J Health Econ*. 2009;28:413-26.
- Shils ME, Shike M, Ross AC, Caballero B, Cousins RJ. Modern nutrition in health and disease. 10<sup>th</sup> ed. Baltimore: Lippincott Williams & Wilkins; 2005.
- ud Din Z, Emmett P, Steer C, Emond A. Growth outcomes of weight faltering in infancy in ALSPAC. *Pediatrics*. 2013;131:e843-9.